Australia's National
Science Agency

The 2021 Antarctic Ozone Hole

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Contents

1 Summary

For the 2021 ozone hole we will be reporting images and metrics calculated from the OMPS data products (see the instrumentation section for a description of these). Please note the OMPS data used in this report are the Level 3 data created from Version 2 (V2.1) of the Nadir Mapper (NM) dataset from the Suomi National Polar-orbiting Partnership satellite.

1.1 August

The first excursions below 220 DU of the ozone minima occurred briefly on a couple of occasions in July. Since 5 August, the ozone minima has remained below 220 DU, dropping to about 190 DU on 5 & 6 August before returning to about average levels for this time of year. From 7 to 23 August the ozone minima approximately followed the mean levels for this time of year, ending at 187 DU on 23 August. The third week of August saw a rapid increase in the ozone hole area reaching 6.6 million km^2 on 15 August, and by 21 August it had reached 10.2 million km^2 before dropping back to 8.7 million km^2 on 23 August. By 23 August the estimated daily ozone deficit had reached a modest 2.4 million tonnes. From the total column ozone images, small patches of ozone depletion can be seen forming in the fringes of the Antarctic polar night (which still covers most of Antarctica at this time of year) from 8-14 August. From 15-23 August, the ozone hole can be seen forming in earnest around the polar night terminator. The strong ridge of high ozone that is normally present in the band immediately south of Australia between about 40-60°S is weaker and appears more-patchy in nature in 2021 compared to previous years. From early-June to the end of July, there was a stratospheric cooling event which saw the heat flux at both the 50 & 100 hPa levels move into record high levels for part of Jun and most of July, which resulted in the 60-90°S zonal mean temperatures at both 50 & 100 hPa being at or close to record low levels for much of June and July. August saw the heat flux at both the 50 & 100 hPa levels return to close to the 70th percentile mark of the 1979-2020 range with the 60-90°S zonal mean temperatures at both 50 & 100 hPa moving to be at about the 10th percentile mark, indicating relatively cold temperatures in the mid to lower stratosphere for this time of year. The forecast is suggesting that these conditions will persist for the coming week.

During the last week of August the 60-90°S zonal mean temperatures at both 50 & 100 hPa continued at about the 10th percentile mark, remaining relatively cold for this time of year. The forecast, however, is suggesting that there will be a small warming event in the coming week. The fourth week of August saw the ozone hole area continue to increase, reaching 13.7 million km^2 by 29 August, the daily ozone deficit increased quite rapidly reaching 7.4 million tonnes, and the daily ozone minima dropped rapidly reaching 146 DU (which is in the lowest 10th percentile of the 1979-2020 range for this time of year). The total column images from 24-29 August clearly show the 2021 ozone hole continuing to form around the polar night with quite a deep pool of ozone depletion to the south of Australia and New Zealand at around -75°S. The coming week should see the ozone hole become fully formed.

1.2 September

During the first week of September the daily ozone hole area increased rapidly reaching 20.4 million km^2 on 3 September, before dropping back to 16.8 million km^2 by 5 September. The variability in the ozone hole area at this time of year is due to variations in the ozone hole formation around the polar night and whether the 220 DU contour that defines the ozone hole is fully closed or not. The daily ozone deficit reached 9.3 million tonnes by 5 September while the daily ozone minima showed some variability but ended at 144 DU by 5 September. The total column ozone images from 30 August to 5 September show the ozone hole forming in earnest, with the hole briefly becoming fully formed on 2 & 3 September, with just a small break in the hole on 4 & 5 September. The coming week will see the ozone hole become fully formed. The small warming event that was forecast did occur during the first week of September whereby the 45-75°S heat flux at both 50 & 100 hPa returned to close to the mean for this time of year. The 60-90°S zonal mean temperatures at both 50 & 100 hPa exhibited a corresponding increase to be in the lower 30th-50th percentile of 1979-2020 range before dropping back down into the 10th-30th percentile range by the end of the first week of September.

The total column ozone images for 6 through to 12 September show that the 2021 Antarctic ozone hole became fully formed on 8 September with the Australian and New Zealand Antarctic stations all within, or on the edge of the ozone hole from 8-12 September. The ozone hole/polar vortex appears to be very stable with the images from 8-12 September showing a very symmetrical ozone hole. The meteorology during the second week of September supports this, with the relatively cold stratospheric conditions seen so far in 2021 continuing, and along with other metrics is indicating potentially another super polar vortex (strong and stable) in 2021 (pers. comm. Harry Hendon and colleagues). The second week of September saw the daily ozone hole area increase from 15.6 million km^2 on 6 September to 22.7 million km^2 by 12 September, with the daily ozone deficit increasing rapidly to be at 17.3 million tonnes by 12 September. The daily ozone minima remained relatively constant during this period in the range of 138 – 147 DU, ending at 146 DU on 12 September.

During the third week of September the daily ozone hole area remained relatively constant at approximately 23 million km^2, reaching 23.4 million km^2 on 15 September and ending at 23.2 million km^2 on 19 September. This time of year is when the peak daily ozone hole area is usually seen, so the peak ozone hole area for 2021 will likely be known in the next 1-2 weeks. For the other metrics, the third week of September saw the daily ozone deficit at 23.7 million tonnes by 19 September, and the daily ozone minima drop sharply reaching 112 DU by 18 September (at the lowest 10th percentile mark of the 1979-2020 range), before rising to be at 119 DU on 19 September. The total column ozone images from 13 to 19 September continue to show a very stable polar vortex with the images from 17-19 September showing a small distortion in the ozone hole/polar vortex. The Antarctic stations of Mawson, Davis and Arrival Heights were all within the ozone hole during 13-19 September, while Casey station was on the edge of, or just outside of the ozone hole during this period. By the end of third week of September the 45-75°S heat flux at both 50 & 100 hPa was at the 90th percentile mark of the 1979-2020 range, with the forecast suggesting that the heat flux at both levels will move into the upper 10th percentile in the coming week. The 60-90°S zonal mean temperature at 50 hPa entered and remained in the lowest 10th percentile band of the 1979-2020 range during the third week of September, with the forecast predicting that in the coming week it will be at record low levels for this time of year. The 100 hPa 60-90°S zonal mean temperature remained in the 10th-30th percentile range during the third week of September.

The meteorological conditions continue to indicate a very strong and stable polar vortex again this year, with the 45-75°S heat flux at both 50 & 100 hPa in the upper 10th percentile of the 1979-2020 range in the fourth week of September, and the 100 hPa trace at, or near, record levels for this time of year. The 60-90°S zonal mean temperature at 50 hPa was at, or near, record low levels during the fourth week of September, while the 100 hPa 60-90°S zonal mean temperature entered the lowest 10th percentile band. The forecast is for these conditions to continue in the coming week. The strong and stable vortex is shown in the total column ozone images as a very symmetrical ozone hole during 20-26 September. Once again, the Antarctic stations of Mawson, Davis and Arrival Heights were all within the ozone hole during 20-26 September, while Casey station was predominantly on the edge of, or just outside of the ozone hole during this period. The fourth week of September saw the daily ozone hole area peak at 24.5 million km^2 on 25 September, which is the largest to date this season and close to the peak ozone hole area in 2020, before dropping back to 24.0 million km^2 on 26 September. The daily ozone deficit increased considerably to be at 30.7 million tonnes by 26 September, while the daily ozone hole minima dropped to 106 DU on 25 September, before increasing marginally to 108 DU on 26 September.

2 The 2021 ozone hole – metrics

2.1 Ozone hole area

Figure 1 shows that during July there were some minor ozone depletion events, however, the first two weeks of August is when the ozone hole started to form in the fringes around the polar night, reaching relatively small areas of about 2.5 million km^2. The third week of August saw a rapid increase in the ozone hole area reaching 6.6 million km^2 on 15 August, and by 21 August it had reached 10.2 million km^2 before dropping back to 8.7 million km^2 on 23 August. The fourth week of August saw the ozone hole area continue to increase, reaching 13.7 million km^2 by 29 August.

During the first week of September the daily ozone hole area increased rapidly, typical for this time of year, reaching 20.4 million km^2 on 3 September, before dropping back to 16.8 million km^2 by 5 September. The variability in the ozone hole area at this time of year is due to variations in the ozone hole formation around the polar night and whether the 220 DU contour that defines the ozone hole is fully closed or not. The second week of September saw the daily ozone hole area increase from 15.6 million km^2 on 6 September to 22.7 million km^2 by 12 September, close to the 70th percentile mark of the 1979-2020 range for this time of year. During the third week of September the daily ozone hole area remained relatively constant at approximately 23 million km^2, reaching 23.4 million km^2 on 15 September and ending at 23.2 million km^2 on 19 September. This time of year is when the peak daily ozone hole area is usually seen, so the peak ozone hole area for 2021 will likely be known in the next 1-2 weeks. The fourth week of September saw the daily ozone hole area peak at 24.5 million km^2 on 25 September, which is the largest to date this season and close to the peak ozone hole area in 2020, before dropping back to 24.0 million km^2 on 26 September.

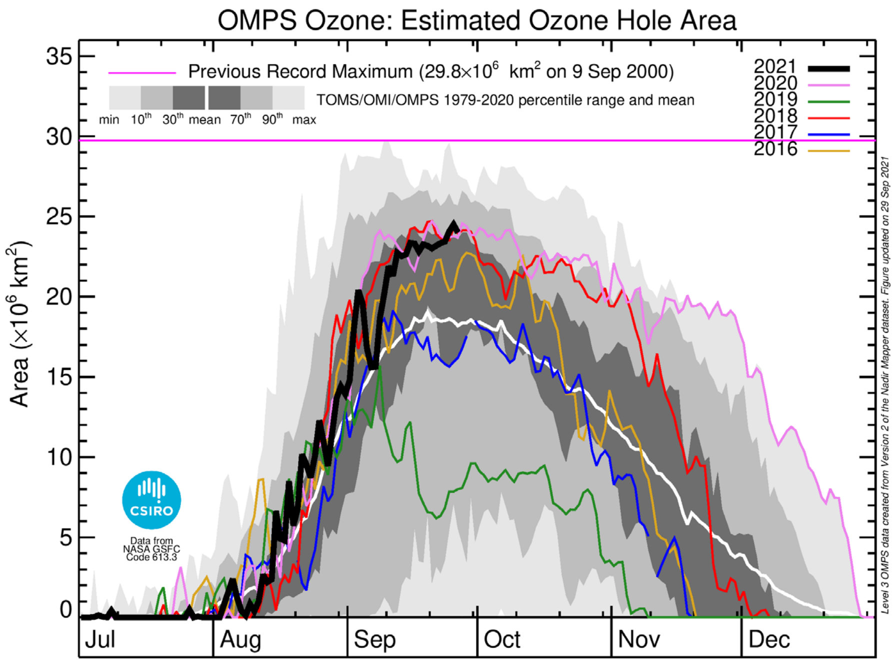

Figure 1 Ozone hole area based on OMPS satellite data (data up to 26 September 2021).

2.2 Ozone deficit

Figure 2 shows that it wasn't until the third week of August that there were substantial levels ozone depletion, with the estimated daily ozone deficit reaching 2.4 million tonnes during 21-23 August. During the fourth week of August, the daily ozone deficit increased quite rapidly, reaching 7.4 million tonnes by 29 August.

The first week of September saw a modest increase in the daily ozone deficit, reaching 9.3 million tonnes by 5 September, similar to the long-term average for this time of year. During the second week of September the daily ozone deficit increased rapidly to be at 17.3 million tonnes by 12 September. The third week of September saw a brief plateau in the daily ozone deficit at 21.5 million tonnes before increasing again to be at 23.7 million tonnes by 19 September. During the fourth week of September the daily ozone deficit increased considerably to be at 30.7 million tonnes by 26 September.

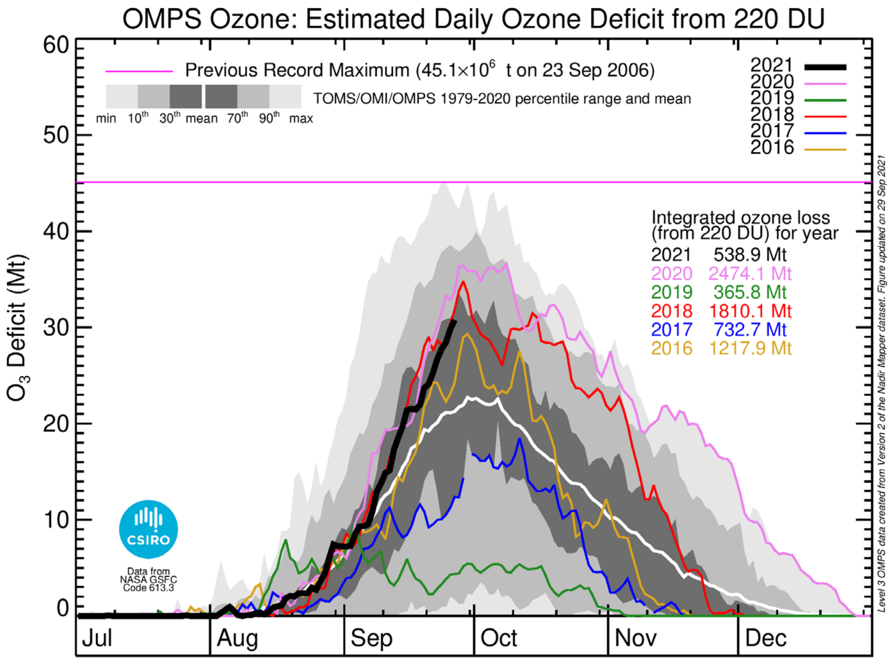

Figure 2 Estimated daily ozone deficit based on OMPS satellite data (2021 data date range as in Figure 1).

2.3 Ozone hole minima

The first excursions below 220 DU of the ozone minima (Figure 3) occurred briefly on 4-8 July to about 210-215 DU around the fringes of the polar night, and again on 26 & 28 July. Since 5 August, the ozone minima remained below 220 DU, dropping to about 190 DU on 5 & 6 August before returning to about average levels for this time of year. From 7 to 23 August the ozone minima approximately followed the mean levels for this time of year, ending at 187 DU on 23 August. This metric can be highly variable at this time of year, but the variability is expected to reduce in the next two to three weeks as the polar night reduces, and the ozone hole fully forms. There was a rapid drop in the daily ozone minima during the fourth week of August, reaching 146 DU on 29 August, which is in the lowest 10th percentile of the 1979-2020 range for this time of year.

Similar to the ozone hole area, the daily ozone minima during the first week of September showed some large variability, rising from the low of 146 DU on 29 August, to 170 DU on 3 September, then down to 144 DU by 5 September. During 6-12 September, the daily ozone minima remained relatively constant in the range of 138 – 147 DU, ending at 146 DU on 12 September. The third week of September saw the daily ozone minima drop sharply again reaching 112 DU by 18 September, which is at the lowest 10th percentile mark of the 1979-2020 range, before rising to be at 119 DU on 19 September. The daily ozone hole minima dropped to 106 DU on 25 September, before increasing marginally to 108 DU on 26 September.

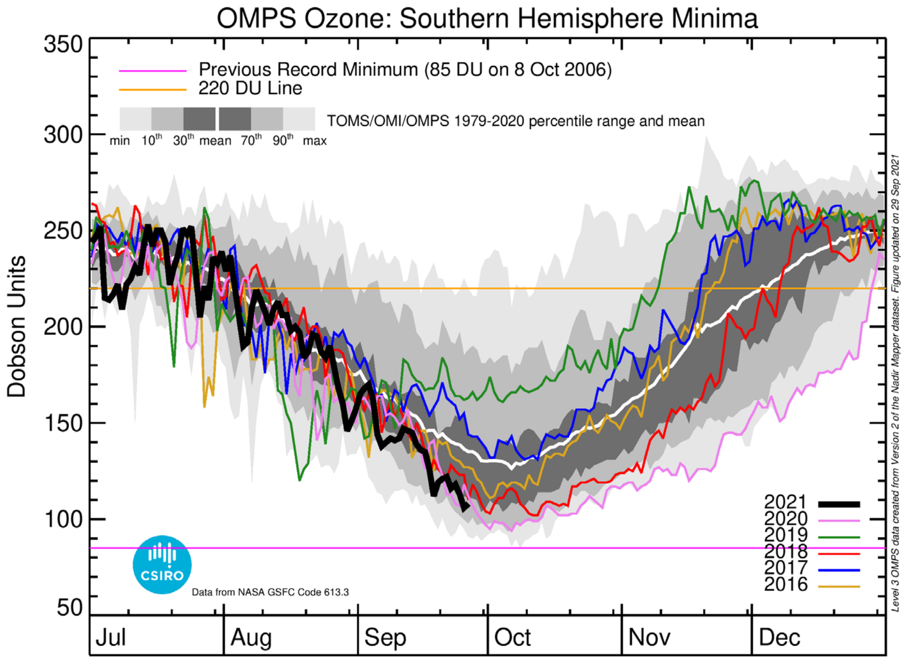

Figure 3 Ozone hole depth based on OMPS satellite data (2021 data date range as in Figure 1).

2.4 Average ozone in the hole

The average ozone amount in the hole (averaged column ozone amount in the hole weighted by area; Figure 4) shows a similar pattern to that of the ozone hole minima. The average ozone amount dropped to about 200 DU on 5 & 6 August, before returning to near average levels. On 23 August the average ozone amount in the hole was 207 DU. By 29 August, the average amount of ozone in the whole had dropped relatively rapidly to be at 195 DU, which is in the 10th-30th percentile band of the 1979-2020 range.

By 5 September, the average amount of ozone within the hole had dropped to 194 DU. During the second week of September the average ozone amount in the hole continued to decline, reaching 185 DU by 12 September. The steady decline in the average amount of ozone within the hole continued during the third week of September, reaching 172 DU by 19 September. The fourth week of September saw the average amount of ozone within the hole continue to decline, reaching 160 DU by 26 September.

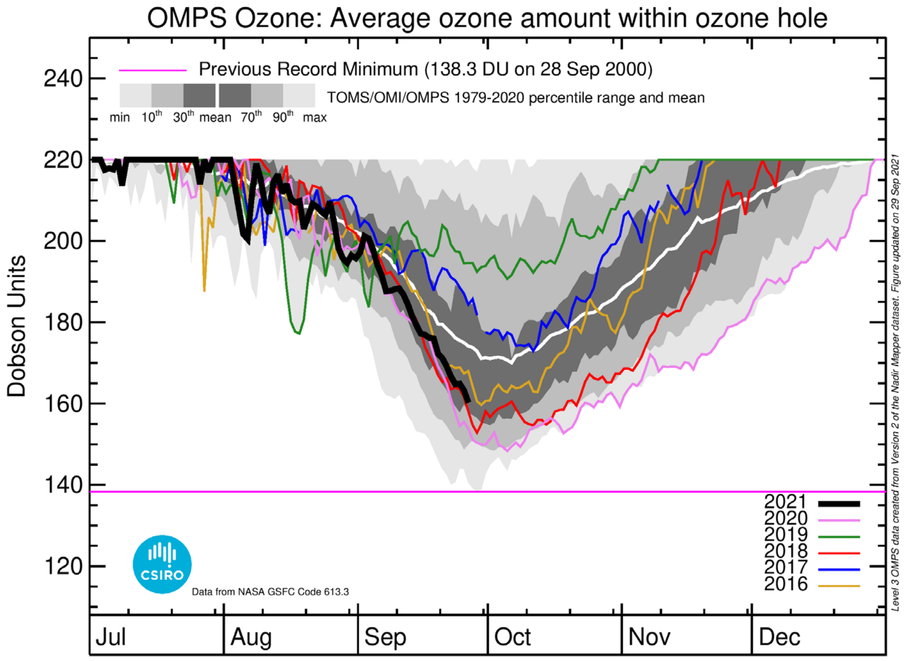

Figure 4 Average ozone amount within the ozone hole based on OMPS satellite data (2021 data date range as in Figure 1).

3 Total column ozone images

The most recent 16 days of total column ozone 'images' over Australia and Antarctica from OMPS are shown in Figure 5.

From the total column ozone images, small patches of ozone depletion can be seen forming in the fringes of the Antarctic polar night (which still covers most of Antarctica at this time of year) from 8-14 August. From 15 August until 23 August, the ozone hole can be seen forming in earnest around the polar night terminator. The strong ridge of high ozone that is normally present in the band immediately south of Australia between about 40-60°S is weaker and appears more-patchy in nature in 2021 compared to previous years. The total column images from 24-29 August clearly show the 2021 ozone hole continuing to form around the polar night with quite a deep pool of ozone depletion to the south of Australia and New Zealand at around -75°S. The coming week should see the ozone hole become fully formed.

The total column ozone images from 30 August to 5 September show the ozone hole forming in earnest, with the hole briefly becoming fully formed on 2 & 3 September, with just a small break in the hole on 4 & 5 September. The coming week will see the ozone hole become fully formed. There is now also a ridge of high ozone to the south of Australia around 50-60°S. The images for 6 through to 12 September show that the 2021 Antarctic ozone hole became fully formed on 8 September with the Australian and New Zealand Antarctic stations all within, or on the edge of the ozone hole from 8-12 September. The ozone hole/polar vortex appears to be very stable with the images from 8-12 September showing a very symmetrical ozone hole. The images from 13 to 19 September continue to show a very stable polar vortex with the images from 17-19 September showing a small distortion in the ozone hole/polar vortex. The Antarctic stations of Mawson, Davis and Arrival Heights were all within the ozone hole during 13-19 September, while Casey station was on the edge of, or just outside of the ozone hole during this period. The ozone hole/polar vortex continued to be very stable during 20-26 September with the total column ozone images showing a very symmetrical ozone hole. Once again, the Antarctic stations of Mawson, Davis and Arrival Heights were all within the ozone hole during 20-26 September, while Casey station was predominantly on the edge of, or just outside of the ozone hole during this period.

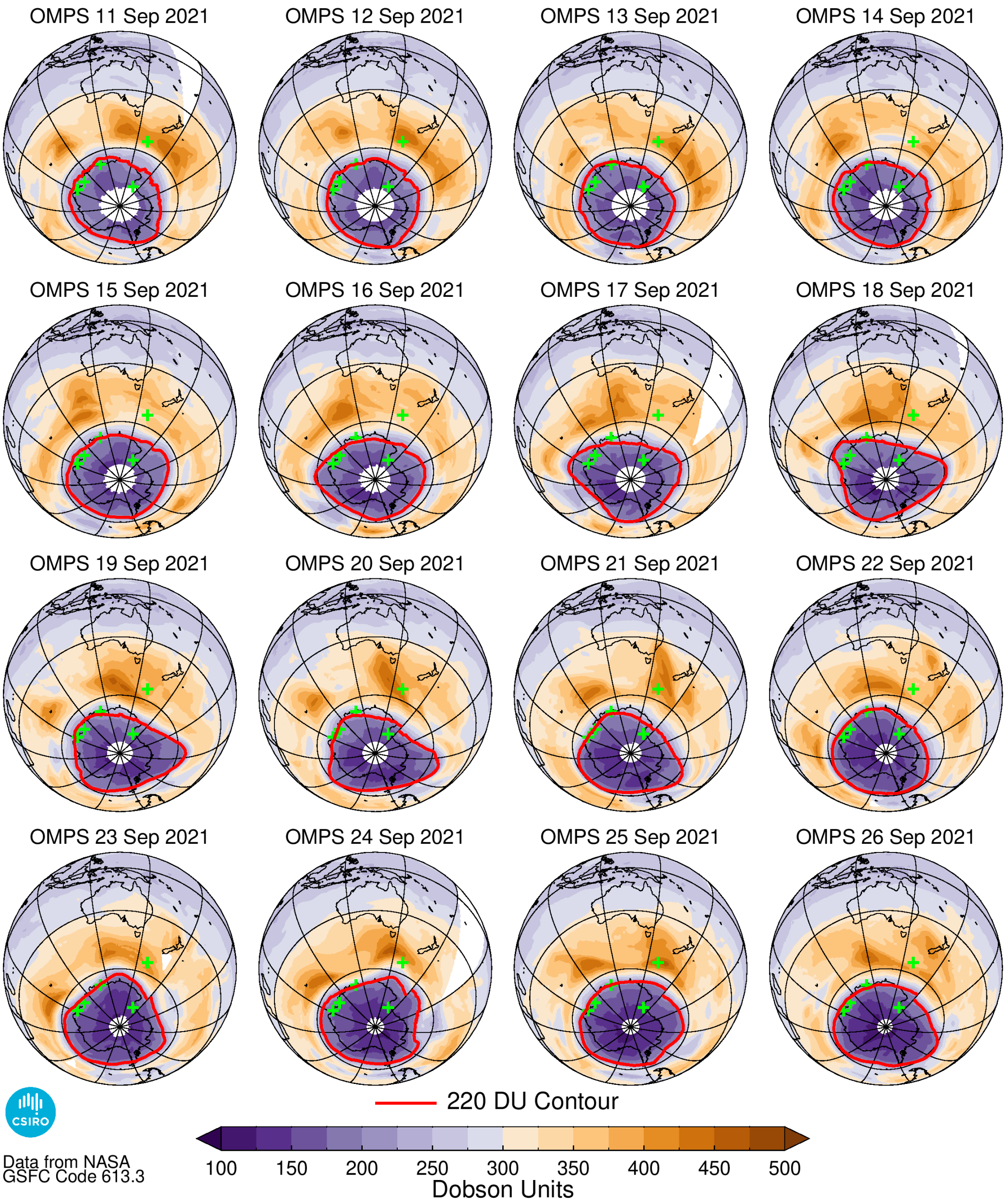

Figure 5 OMPS ozone hole images for 11 – 26 September; the ozone hole boundary is indicated by the red 220 DU contour line. Green plus symbols indicate the location of the Australian Antarctic stations of Mawson (62.9°E, 67.6°S), Davis (78.0°E, 68.6°S) and Casey (110.5°E, 66.3°S), the New Zealand Antarctic station of Arrival Heights (166.7°E, 77.8°S) and Macquarie Island station (158.9°E, 54.5°S). The white area over Antarctica is missing data and indicates the approximate extent of the polar night. The OMPS instrument requires solar radiation to the earth's surface in order to measure the column ozone abundance.

4 NASA MERRA heat flux and temperature

The MERRA 45-day mean 45-75°S heat fluxes at 50 & 100 hPa are shown in the left column of Figure 6. A less negative heat flux usually results in a colder polar vortex, while a more negative heat flux indicates heat transported towards the pole (via meteorological disturbances/waves) and results in a warming of the polar vortex. The corresponding 60-90°S zonal mean temperatures at 50 & 100 hPa are shown in the right column of Figure 6, these usually show an anti-correlation to the heat flux.

At 50 hPa, the type 1 PSC (HNO3.3H2O) formation threshold temperature (195 K) was reached in mid-June. At 100 hPa, the threshold temperature was reached at the end of June.

4.1 May, June, July, August

During May, 45-day mean 45-75°S heat flux at 50 hPa was in initially the 10-30th percentile moving into the 30-50th percentile of the 1979-2020 range towards the end of the month, while at 100 hPa it was predominantly in the 10-30th percentile, indicating more heat transport towards the pole than average. The corresponding 60-90°S zonal mean temperatures at both 50 & 100 hPa were very close to the average during May. From early-June to the end of July, there was a cooling event which saw the heat flux at both the 50 & 100 hPa levels move into record high levels for part of Jun and most of July. This resulted in the 60-90°S zonal mean temperatures at both 50 & 100 hPa being at or close to record low levels for much of June and July. August (up to 24 August) saw the heat flux at both the 50 & 100 hPa levels return to close to the 70th percentile mark of the 1979-2020 range. Correspondingly, the 60-90°S zonal mean temperatures at both 50 & 100 hPa moved to be at about the 10th percentile mark, indicating relatively cold temperatures in the mid to lower stratosphere for this time of year. The forecast is suggesting that these conditions will persist for the coming week.

The last week of August saw the 45-75°S heat flux at 50 & 100 hPa remain around the 70th percentile mark of the 1979-2020 range, while the 60-90°S zonal mean temperatures at both 50 & 100 hPa continued at about the 10th percentile mark, remaining relatively cold for this time of year. The forecast, however, is suggesting that there will be a small warming event in the coming week with the 45-75°S heat flux at both 50 & 100 hPa returning to close to the mean for this time of year, with the 60-90°S zonal mean temperatures at both 50 & 100 hPa showing modest increases before cooling slightly again.

4.2 September

The small warming event that was forecast did occur during the first week of September whereby the 45-75°S heat flux at both 50 & 100 hPa returned to close to the mean for this time of year. The 60-90°S zonal mean temperatures at both 50 & 100 hPa exhibited a corresponding increase to be in the lower 30th-50th percentile of 1979-2020 range before dropping back down into the 10th-30th percentile range by the end of the first week of September. The forecast is for similar conditions to continue, with the 50 hPa 60-90°S zonal mean temperature to drop into the lowest 10th percentile in the coming week.

The second week of September saw the 45-75°S heat flux at both 50 & 100 hPa move back into the 70-90th percentile of 1979-2020 range, indicating less heat transport towards the pole, which is consistent with a very stable polar vortex. The 60-90°S zonal mean temperatures at both 50 & 100 hPa remained in the 10th-30th percentile range during the second week of September, with the trace at 50 hPa ending at the 10th percentile mark. This continues the very cold stratospheric conditions seen so far in 2021 and along with other metrics is indicating potentially another super polar vortex in 2021 (pers. comm. Harry Hendon and colleagues).

By the end of third week of September the 45-75°S heat flux at both 50 & 100 hPa was at the 90th percentile mark of the 1979-2020 range, with the forecast suggesting that the heat flux at both levels will move into the upper 10th percentile in the coming week, and for the 100 hPa trace to be at record levels for this time of year. The 60-90°S zonal mean temperature at 50 hPa entered and remained in the lowest 10th percentile band of the 1979-2020 range during the third week of September, with the forecast predicting that in the coming week it will be at record low levels for this time of year. The 100 hPa 60-90°S zonal mean temperature remained in the 10th-30th percentile range during the third week of September with the forecast suggesting it will enter the lowest 10th percentile band be the end of the fourth week of September.

The fourth week of September saw the 45-75°S heat flux at both 50 & 100 hPa move into the upper 10th percentile of the 1979-2020 range, with the 100 hPa trace at, or near, record levels for this time of year. The forecast is suggesting that the heat flux at both levels will remain in the upper 10th percentile in the coming week. The 60-90°S zonal mean temperature at 50 hPa was at, or near, record low levels during the fourth week of September, with the forecast predicting that in the coming week it will remain at, or near, record low levels for this time of year. The 100 hPa 60-90°S zonal mean temperature entered the lowest 10th percentile band during the fourth week of September, with the forecast suggesting it will remain there in the coming week. These conditions continue to indicate a very strong and stable polar vortex again this year.

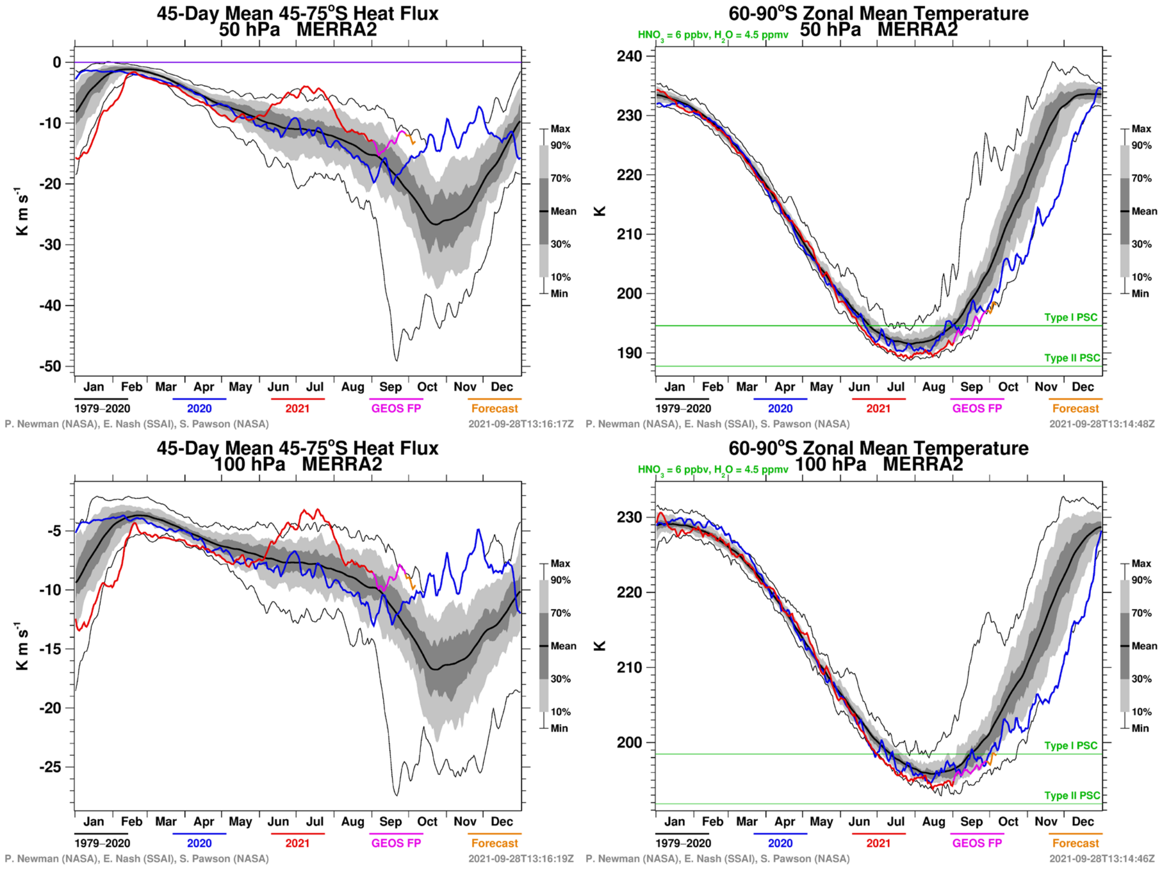

Figure 6 MERRA2 45-day mean 45°S-75°S eddy heat flux and 60°S-90°S zonal mean temperature at 50 & 100 hPa. Images courtesy of NASA GSFC, downloaded 29 September 2021, data through to 6 October 2021 (data starting 2021-09-01 are from GEOS FP; 2021-09-28 onwards are forecasts): http://ozonewatch.gsfc.nasa.gov/meteorology/SH.html

5 Satellite Instrumentation

5.1 OMPS

OMPS (Ozone Mapping and Profiler Suite) is an ozone instrument on the Suomi National Polar-orbiting Partnership satellite (Suomi NPP), which was launched on 28 October 2011 and placed into a sun-synchronous orbit 824 km above the Earth. The partnership is between NASA, NOAA and DoD (Department of Defense), see https://www.jpss.noaa.gov/ for more details. OMPS continues the US program for monitoring the Earth's ozone layer using advanced hyperspectral instruments that measure sunlight in the ultraviolet and visible, backscattered from the Earth's atmosphere, and will contribute to observing the recovery of the ozone layer in coming years. For the 2021 ozone hole season, we will be using the OMPS total column ozone data and will be producing metrics from both OMI and OMPS Level 3 global gridded daily total ozone column products from NASA, and present both sets of results for comparison. The OMPS data used in this report are the Level 3 data created from Version 2.1 (V2.1) of the Nadir Mapper (NM) dataset from Suomi-NPP's Ozone Mapping and Profiler Suite (OMPS).

6 Archive of the weekly reports

The weekly Antarctic Ozone Hole reports for the 2021 ozone hole season are available from the Department of the Environment and Energy web page here:

http://www.environment.gov.au/protection/ozone/publications/antarctic-ozone-hole-summary-reports

7 Definitions

CFCs: chlorofluorocarbons, synthetic chemicals containing chlorine, once used as refrigerants, aerosol propellants and foam-blowing agents, that break down in the stratosphere (15-30 km above the earth's surface), releasing reactive chlorine radicals that catalytically destroy stratospheric ozone.

DU: Dobson Unit, a measure of the total ozone amount in a column of the atmosphere, from the earth's surface to the upper atmosphere, 90% of which resides in the stratosphere at 15 to 30 km.

Halons: synthetic chemicals containing bromine, once used as fire-fighting agents that break down in the stratosphere releasing reactive bromine radicals that catalytically destroy stratospheric ozone. Bromine radicals are about 50 times more effective than chlorine radicals in catalytic ozone destruction.

MERRA: is a NASA reanalysis for the satellite era using a major new version of the Goddard Earth Observing System Data Assimilation System Version 5 (GEOS-5). The project focuses on historical analyses of the hydrological cycle in a broad range of weather and climate time scales. It places modern observing systems (such as EOS suite of observations) in a climate context. Since these data are from a reanalysis, they are not up-to-date. So, NASA supplement with the GEOS-5 FP data that are also produced by the GEOS-5 model in near real time. These products are produced by the NASA Global Modeling and Assimilation Office (GMAO).

MERRA2: MERRA2 was introduced to replace the original MERRA dataset because of the advances made in the assimilation system that enable assimilation of modern hyperspectral radiance and microwave observations, along with GPS-Radio Occultation datasets. It also uses NASA ozone observations after 2005. Additional advances in both the GEOS-5 model and the GSI assimilation system are included in MERRA-2.

Ozone: a reactive form of oxygen with the chemical formula O3; ozone absorbs most of the UV radiation from the sun before it can reach the earth's surface.

Ozone Hole: ozone holes are examples of severe ozone loss brought about by the presence of ozone depleting chlorine and bromine radicals, whose levels are enhanced by the presence of PSCs (polar stratospheric clouds), usually within the Antarctic polar vortex. The chlorine and bromine radicals result from the breakdown of CFCs and halons in the stratosphere. Smaller ozone holes have been observed within the weaker Arctic polar vortex.

Polar night terminator: the delimiter between the polar night (continual darkness during winter over the Antarctic) and the encroaching sunlight. By the first week of October the polar night has ended at the South Pole.

Polar vortex: a region of the polar stratosphere isolated from the rest of the stratosphere by high west-east wind jets centred at about 60°S that develop during the polar night. The isolation from the rest of the atmosphere and the absence of solar radiation results in very low temperatures (< -78°C) inside the vortex.

PSCs: polar stratospheric clouds are formed when the temperatures in the stratosphere drop below -78°C, usually inside the polar vortex. This causes the low levels of water vapour present to freeze, forming ice crystals and usually incorporates nitrate or sulphate anions.

TOMS, OMI & OMPS: the Total Ozone Mapping Spectrometer (TOMS), Ozone Monitoring Instrument (OMI), and Ozone Mapping and Profiler Suite (OMPS) are satellite borne instruments that measure the amount of back-scattered solar UV radiation absorbed by ozone in the atmosphere; the amount of UV absorbed is proportional to the amount of ozone present in the atmosphere.

UV radiation: a component of the solar radiation spectrum with wavelengths shorter than those of visible light; most solar UV radiation is absorbed by ozone in the stratosphere; some UV radiation reaches the earth's surface, in particular UV-B which has been implicated in serious health effects for humans and animals; the wavelength range of UV-B is 280-315 nanometres.

8 Acknowledgements

The TOMS and OMI data are provided by the TOMS ozone processing team, NASA Goddard Space Flight Center, Atmosp heric Chemistry & Dynamics Branch, Code 613.3. The OMI instrument was developed and built by the Netherlands's Agency for Aerospace Programs (NIVR) in collaboration with the Finnish Meteorological Institute (FMI) and NASA. The OMI science team is led by the Royal Netherlands Meteorological Institute (KNMI) and NASA. The OMPS Level 3 data used in this report were created from a research dataset developed by NASA's NPP Ozone Science Team using nadir mapper measurements from Suomi-NPP's Ozone Mapping and Profiler Suite (OMPS). All data were downloaded from either the NASA Ozone Watch webpage https://ozonewatch.gsfc.nasa.gov/ or the NASA Earth Data Near Real Time data portal https://earthdata.nasa.gov/earth-observation-data/near-real-time/download-nrt-data/omps-nrt.

The NASA Ozone Watch webpage contains a lot of useful data and information on the Antarctic ozone hole.

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